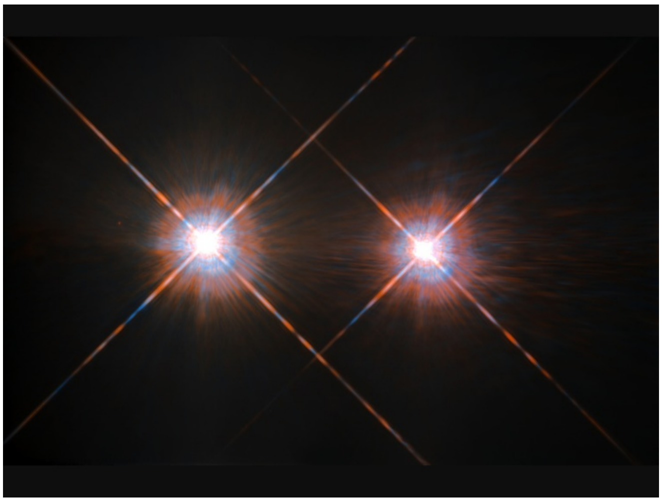
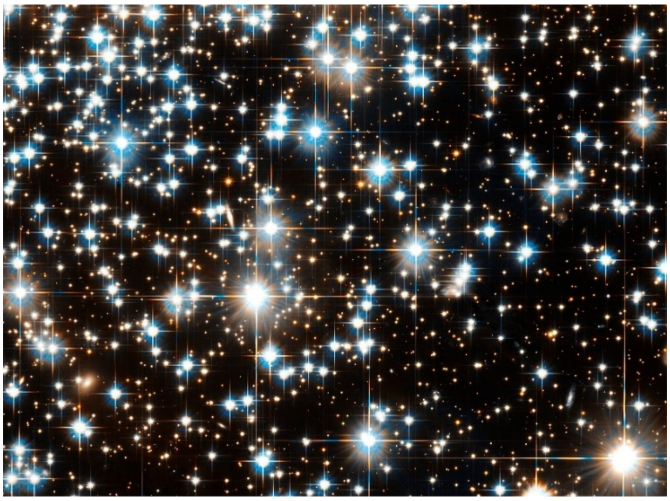
Introduction

The range of Reflecting Objectives produced by Beck Optronic Solutions have straight-legged spiders by default, but curved legged spiders are offered as an option. This document explores the advantages and disadvantages of each option.

The secondary mirror in a Reflecting Objective needs to be supported by a spider. This spider, straight or curved, diffracts energy.
The curved spider support was developed for secondary mirrors in astronomic telescopes. Many people did not like the diffraction cross on bright star images. This cross is visible on the very brightest stars during observation and may well be recorded on film or CCD. It is not used on professional telescopes but seems to be liked in the amateur world for aesthetic reasons. It is notable that the world's most famous telescope, the Hubble Space Telescope, has a spider with straight legs which is obvious in many of the extraordinary photos it has taken, as below.



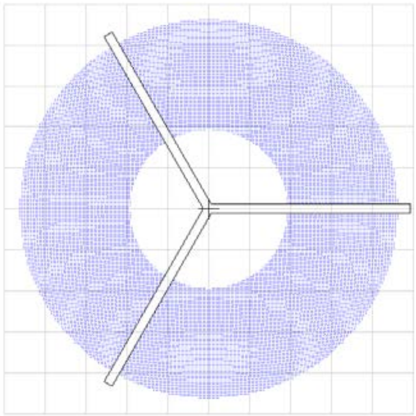


The diffraction lines from the spider are of no scientific consequence.

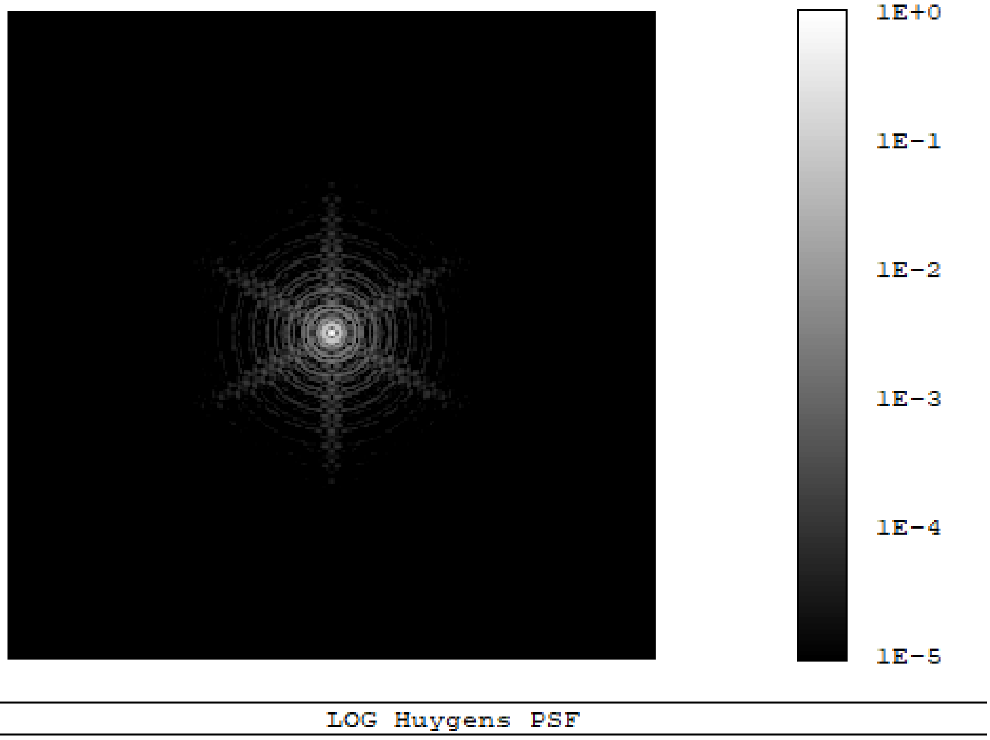
Reflecting Objectives
Reflecting Objectives typically have three or four leg spiders (BOS offers both options). The three-legged spider is usually favoured as it diffracts less energy than the four – this energy diffracted being proportional to the total length of the spider arms. However, the three-armed spider produces six equi-spaced diffraction spikes, but they are significantly fainter than the four spikes of the four-armed spider – the choice depending on the customer application or preference.

In normal circumstances, when imaging extended scenes of contrast range 1000:1, the effect of these spikes cannot be seen or recorded by normal film or sensors. It is only when intense bright points are imaged (beyond sensor saturation in particular) that the diffraction spikes become evident. If these spikes become disturbing in some way, curved support spiders can be considered. They do significantly reduce the energy in the spikes, but it should be noted that the system Modulation Transfer Function (MTF) is practically no different when compared to the straight spider system.

This is the pupil of a reflecting objective (the BOS x15 NA0.28) showing the obscuration caused by the secondary mirror and its mounting 3-armed spider….

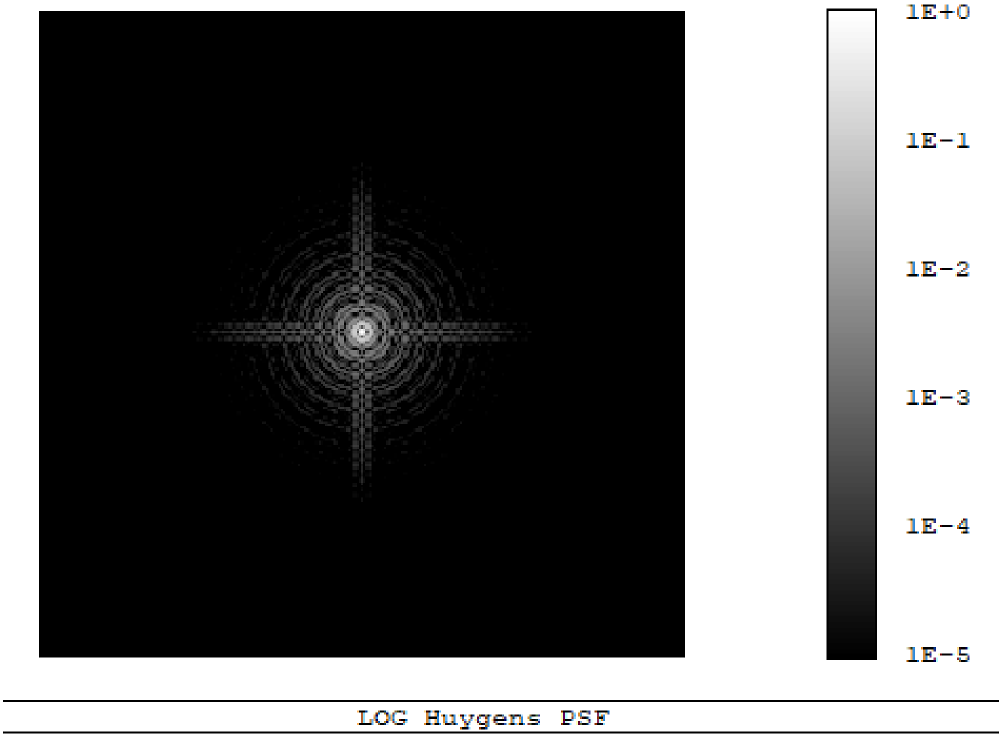


The effect of the spiders can be seen on the following point spread function (the intensity plot of the image of a point source)



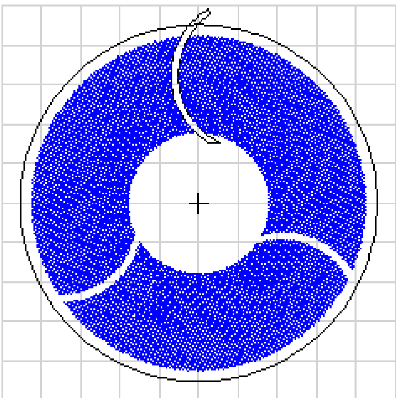
The diffraction spikes caused by the spider are clearly visible but notice that this is plotted on a density range of 100,000:1

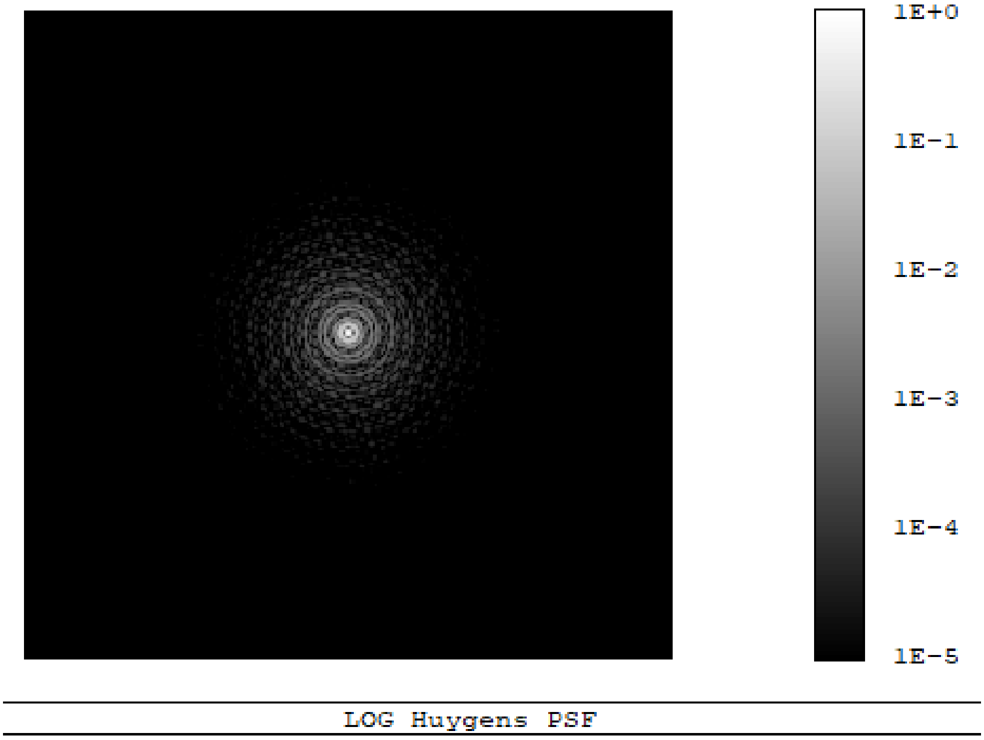
For comparison, this is the equivalent spread function for the four-armed spider version…



Which illustrates why the three-armed spider is generally preferred.

When analysing curved spiders there are several variables: the radius of curvature of the arm, the tilt of the arm, and its width. The arm is usually made the minimum width possible, but the radius does need to be explored. The following is the third iteration of decreasing radius and is the first to show no diffraction spike.





Clearly the diffraction spikes are no longer present. The energy outside the central spot now appears slightly higher than in the Point Spread Function (PSF) with a straight spider and that's because it is – there is slightly more energy in the diffracted orders because, strictly, the curved arms are slightly longer than the straight arms and the energy that was in the spikes is now re-distrubted in the outer area of the PSF.

The MTFs of the curved and straight-armed spider systems are essentially identical.

In conclusion, whilst Beck is able to supply reflecting objectives with curved spiders, it is seldom likely to be worth the extra cost.